INTERNATIONAL STANDARD

ISO 19867-1

First edition
2018-06

Clean cookstoves and clean cooking solutions — Harmonized laboratory test protocols —

Part 1: Standard test sequence for emissions and performance, safety and durability

Fourneaux et foyers de cuisson propres — Protocoles d'essai en laboratoire harmonisés —

Partie 1: Séquence générale d'essais en laboratoire

Reference number
ISO 19867-1:2018(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 www.iso.org/directives.

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 285, *Clean cookstoves and clean cooking solutions*.

A list of all the parts in the ISO 19867 series can be found on the ISO website.

Introduction

This document is intended for use as laboratory measurement procedures to determine performance for cookstoves used primarily for cooking or water heating. Its purpose is to provide metrics that can be used to indicate a cookstove's performance under controlled conditions. This document provides a standard test sequence that can be used to compare the performance of various cookstove types, cookstove fuels, and cooking practices under controlled laboratory test conditions, as specified in this document.

This document was developed to achieve two goals:

a) greater alignment in methodology and metrics around the world, and

b) adaptation of methodology and metrics to the wide variety of cookstove types, cookstove fuels, and cooking practices.

For the purpose of this document, the intended user group refers to the approximately 2,8 billion people worldwide who are currently cooking with open fires or rudimentary stoves.

For evaluation of the performance and predicted outcomes of a cooking system in the field [comprising cookstove(s), fuel(s), cooking vessel(s), kitchen, ventilation, and user(s)], ISO 19869[1)] applies.

This document was developed from best practices from existing cookstove testing protocols, the experience of cookstove testing centres in many countries, and standards and testing methodology in related sectors.

Air pollutant emissions results are expressed in units of mass of pollutant per useful energy delivered and represent the mass of emissions per unit of cooking energy delivered. Emission results are also expressed in units of mass of pollutant per time and represent the mass rate of emission per unit time. Procedures for determining emissions require a complex set of individual measurements, rather than a single measured value. Thus, the results obtained depend as much on the procedure used to perform the measurements as they depend on the cookstove and the test method. The procedure used to perform the complex set of individual measurements is critical to obtaining the results.

Energy efficiency results are expressed as thermal efficiency. Cooking power results are expressed in units of watts.

Safety and durability results are expressed as a points-based rating system to enable individual countries and organizations to select levels based on their priorities. Durability methods are intended to evaluate the aspects of cookstove designs that can affect usable life and consumers' perceptions of quality. Durability testing methods include evaluation of extended runs, quenching, external and internal impacts, coating adhesion, corrosion, and material failure temperature.

1) In preparation.

Clean cookstoves and clean cooking solutions — Harmonized laboratory test protocols —

Part 1: Standard test sequence for emissions and performance, safety and durability

1 Scope

This document is applicable to cookstoves used primarily for cooking or water heating in domestic, small-scale enterprise, and institutional applications, typically with firepower less than 20 kW and cooking vessel volume less than 150 l, excluding cookstoves used primarily for space heating. For solar cookstoves, the provisions of this document are applicable only for evaluating cooking power, safety, and durability. Solar cookstoves have zero on-site emissions, and their cooking power can be determined according to ASAE S 580.1. This document does not cover electric stoves. Safety evaluation of electric stoves can be found in IEC 60335-2-6[62].

This document specifies laboratory measurement and evaluation methods for

a) particulate and gaseous air pollutant emissions,

b) energy efficiency,

c) safety, and

d) durability of cookstoves.

This document does not include evaluation of off-gassing from manufacturing oils, coatings, adhesives, and other materials (which can be found in ISO 10377 and ISO 14159). This document does not include evaluation of safety for cookstoves designed to burn a liquid and/or gaseous fuel, such as LPG (liquefied petroleum gas), alcohol, plant oil, kerosene, etc. Safety evaluation of gas-fuelled cookstoves can be found in ISO 23550 and ISO 23551 (all parts). This document does not include durability evaluation of rechargeable batteries in fan-assisted cookstoves. This document provides a standard test sequence to establish international comparability in measurement of cookstove emissions and efficiency. Guidelines for reporting results from the laboratory measurement and evaluation methods are described. For cookstoves used in applications covered by additional requirements (e.g., local air quality and safety regulations), additional test conditions and special evaluation methods may apply.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ASAE S580.1. Testing and Reporting Solar Cooker Performance, *American Society of Agricultural and Biological Engineers*. Available from https://www.asabe.org/media/200979/s580.1.pdf

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
as fired
condition of a fuel as it is about to be tested in a *cookstove* (3.19)

3.2
as received
condition of a fuel as it is received for testing in a *cookstove* (3.19)

3.3
ash
non-combustible residue remaining after combustion of a fuel under specified conditions, typically expressed as a percentage of the mass of dry matter in fuel

Note 1 to entry: Ash content can be determined using a muffle furnace under a temperature of 580 °C to 600 °C.

3.4
batch-loaded cookstove
cookstove (3.19) into which fuel is infrequently loaded during operation

EXAMPLE Batch-loaded cookstoves can include, but are not limited to, TLUD (top-lit up-draft) stoves.

3.5
biofuels
materials of biological origin used as fuel

EXAMPLE Biofuels can include but are not limited to wood, agricultural residues, dung, biogas, and processed lignocelluloses (e.g. charcoal, briquettes, and pellets).

3.6
black carbon
class of highly light-absorbing carbonaceous aerosols, typically composed largely of *elemental carbon* (3.25)

3.7
built-in-place cookstove
cookstove (3.19) in which the majority of assembly and/or construction takes place where it will be used

3.8
burning rate
rate at which test fuel is consumed in a *cookstove* (3.19), in g [*dry basis* (3.22)] per minute

3.9
burn sequence
combustion of fuel in a *cookstove* (3.19) from *ignition* (3.39) to an end point defined in a specific protocol

3.10
char
carbonaceous residue resulting from pyrolysis or incomplete combustion of solid *biofuels* (3.5)

3.11
char energy efficiency
ratio of the energy of *char* (3.10) produced to the energy of *fuel fed* (3.33), *as fired* (3.1)

3.12
char mass productivity
ratio of the mass of *char* (3.10) produced to the mass of *fuel fed* (3.33)

3.13
continuously fed cookstove
cookstove (3.19) in which fuel is constantly or frequently fed during operation

EXAMPLE Continuously fed cookstoves can include, but are not limited to, rocket stoves.

3.14
cooking efficiency
thermal efficiency (3.57) for *cookstoves* (3.19) used only for cooking

Note 1 to entry: *Thermal efficiency* (3.57) for *space heating* (3.56) can differ from cooking efficiency for *cookstoves* (3.19).

3.15
cooking power
average rate of energy delivered to the contents of a *cooking vessel* (3.18) over any chosen period during the course of a *cooking sequence* (3.16) or other task

Note 1 to entry: The cooking power is expressed in kilowatts.

3.16
cooking sequence
operation of a *cookstove* (3.19) that uses the heat energy released during a *burn sequence* (3.9) for the preparation of food or the heating of water, with a recorded or prescribed series of power level settings, durations, and *cooking vessel* (3.18) utilisations

Note 1 to entry: The *cooking sequence* (3.16) commences with the placement of the first *cooking vessel* (3.18) on the stove and ends when the last cooking vessel is removed.

Note 2 to entry: The entire *cooking sequence* (3.16) is normally embedded within a *burn sequence* (3.9), though in special cases *retained heat cookers* (3.52) might continue cooking after the fire has been extinguished or while additional cooking tasks are undertaken.

3.17
cooking time
elapsed time from the time when the food is placed on the *cookstove* (3.19) to the time that the food is removed from the *cookstove*

3.18
cooking vessel
pot or container in which food or water is heated and prepared

3.19
cookstove
appliance primarily employed for the cooking of food, but which may also be employed for space or water heating, or other purposes

3.20
dilution system
apparatus that mixes a sample stream with air, nitrogen, or other gases of known composition in a controllable ratio

3.21
dilution tunnel
device in which ambient or cleaned air is mixed with an emission stream in a controlled and measured volumetric flow rate

3.22
dry basis
basis for describing the composition of a fuel sample as the ratio of the mass of a component to the mass of a fuel in its *dry fuel* (3.23) state, expressed in percent

3.23
dry fuel
fuel from which most moisture has been removed according to a drying procedure

3.24
durability
ability of a *cookstove* (3.19) to continue to be operated for an extended period in a *safe* (3.53) manner and with minimal loss of performance

3.25
elemental carbon
particulate carbonaceous material emitted during combustion that demonstrates a refractory nature according to a defined thermal-optical protocol

3.26
emission factor
ratio of the mass of a pollutant emitted to a defined measure that quantifies the activity emitting the pollutant

EXAMPLE Potential defined measures for emission factors include the *useful energy delivered* (3.59), mass of the *fuel consumed* (3.31), the dry mass of the *fuel consumed,* or the energy of the *fuel consumed.*

3.27
emission rate
mass of an air pollutant emitted per unit time, reported in units such as mg/h or g/s.

3.28
field
locations where cooking is normally performed in real-world situations, such as homes and target communities

3.29
field testing
observation or measurement of any part or parts of a *cookstove* (3.19) system conducted under various actual use conditions, instead of under controlled conditions in a *laboratory* (3.40)

3.30
firepower
over a specified period in the *burn sequence* (3.9), rate of energy release from the combustion of the fuel assuming complete combustion

Note 1 to entry: The firepower is expressed in kilowatts.

3.31
fuel consumed
mass (kg) of unburned *fuel fed* (3.33) minus mass of *residual fuel* (3.51), if applicable, during a defined *burn sequence* (3.9)

Note 1 to entry: For applicability of *residual fuel* (3.51), see details in testing protocol.

3.32
fuel energy used
product of the *heating value* (3.37) of the *raw fuel* (3.50) and its mass as fired, less the product of the heating value of the *residual fuel* (3.51), if applicable, and its mass

Note 1 to entry: For applicability of *residual fuel* (3.51), see details in testing protocol.

3.33
fuel fed
fuel supplied to a *cookstove* (3.19) during the course of the *burn sequence* (3.9)

3.34
fugitive emissions
emissions that escape from a *cookstove* (3.19) into the surrounding space of the cooking environment, as opposed to emissions that are removed directly from the stove via a chimney

3.35
gravimetric method
quantification of a sample of *particulate matter* (3.46) through the direct measurement of mass

3.36
griddle cookstove
plancha cookstove
cookstove (3.19) with which the majority of cooking occurs by placing the food directly on a heated surface, usually a metal or ceramic plate

Note 1 to entry: Regional terms for a griddle cookstove include *plancha*, comal and mittad.

3.37
heating value
energy per unit mass released in the complete combustion of a sample of fuel, as determined by combustion in a suitable calorimeter

Note 1 to entry: The state of the fuel is specified [*as received* (3.2), *as fired* (3.1), or *dry fuel* (3.23)].

Note 2 to entry: The heating value is specified as either *higher heating value* (3.38) or *lower heating value* (see 3.42).

Note 3 to entry: The heating value is expressed in MJ/kg.

3.38
higher heating value
measured value of the energy of combustion of a fuel burned in oxygen in a bomb calorimeter under such conditions that all the water of the reaction products is in the form of liquid water

Note 1 to entry: See Reference [36].

Note 2 to entry: The heating value is expressed in MJ/kg.

3.39
ignition
initiation of a period of a self-sustained combustion reaction

3.40
laboratory
facility that provides controlled conditions for conducting research and evaluating performance

3.41
laboratory testing
measurement of product performance quantified under controlled and documented conditions, where performance can be replicated by duplicating those conditions

3.42
lower heating value at constant pressure
absolute value of the specific heat (enthalpy) of combustion per unit mass (MJ/kg) of the fuel burned in oxygen at constant pressure under such conditions that all the water of the reaction products remains as water vapour (at 0,1 MPa), the other products being as for the *higher heating value* (3.38), all at the reference temperature

Note 1 to entry: See Reference [43].

3.43
maximum cooking power
highest *cooking power* (3.15) for which a *cookstove* (3.19) is designed

Note 1 to entry: The maximum cooking power is expressed in kW.

3.44
minimum cooking power
lowest *cooking power* (3.15) for which a *cookstove* (3.19) is designed

Note 1 to entry: The minimum cooking power is expressed in kW.

3.45
organic carbon
carbonaceous material emitted during combustion in which the carbon is chemically bonded to hydrogen and possibly also oxygen, nitrogen, sulphur, or other elements

3.46
particulate matter
solid and liquid matter of a sufficiently small size to be suspended in gas

3.47
pot skirt
device that encircles a *cooking vessel* (3.18) for the purpose of increasing heat transfer to the *cooking vessel*

Note 1 to entry: A pot skirt can be a design feature or addition to the *cookstove* (3.19), or an integral part of a specialized *cooking vessel* (3.18).

3.48
$PM_{2,5}$
fine *particulate matter* (3.46) such that the aerodynamic diameter of the particles is less than or equal to 2,5 µm

3.49
procedures
systematic methods specified for accomplishing certain tasks related to the testing or assessment of *cookstoves* (3.19)

3.50
raw fuel
mass of unburned fuel supplied to a *cookstove* (3.19) during the course of a *burn sequence* (3.9)

3.51
residual fuel
material [typically *char* (3.10)] that has a usable energy content that remains after a *burn sequence* (3.9) is completed

3.52
retained heat cooker
insulated container that can accommodate one or more *cooking vessels* (3.18) that have been heated on a *cookstove* (3.19)

3.53
safe
capacity to be used at an acceptable level of risk of harm

3.54
safety
ability of a *cookstove* (3.19) to be operated at an acceptable level of risk of harm

3.55
solar cookstove
device that delivers useful cooking heat from energy received from the sun

3.56
space heating
delivery of useful heat from a heat source into a household or other indoor space

3.57
thermal efficiency
ratio of *useful energy delivered* (3.59) to *fuel energy used* (3.32)

3.58
traditional cookstove
type of *cookstove* (3.19) or three-stone open fire that has been in long existence in a region and has been established from generation to generation

3.59
useful energy delivered
energy transferred to the contents of a *cooking vessel* (3.18), including sensible heat energy that raises the temperature of the contents of the *cooking vessel* and the latent heat of evaporation of water from the *cooking vessel*

Note 1 to entry: For *cookstoves* (3.19) that are used for both cooking and *space heating* (3.56), useful energy delivered may also include heat delivered to a living space.

3.60
water heater
appliance designed to transfer heat into one or more water containers

3.61
wet basis
basis for describing the composition of a fuel sample as the ratio of the mass of a component to the mass of a fuel in its *as received* (3.2) state, expressed in percent

4 Symbols and abbreviated terms

ASTM	American Society for Testing and Materials
BC	black carbon
C	carbon
CI	confidence interval
CO	carbon monoxide
CO_2	carbon dioxide
D	diameter
dscm	dry standard cubic metre
EC	elemental carbon
EF	emission factor
EPA	U.S. Environmental Protection Agency
H	hydrogen